

4 August 1965

TECP 700-700
Materiel Test Procedure 2-2-604*
Aberdeen Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURES

DRAWBAR PULL

1. OBJECTIVE

This document sets forth the minimum data requirements for evaluation and comparison of drawbar pull characteristics of both wheeled and tracked vehicles on hard-surfaced roads; in adverse soils; and, for amphibious vehicles, in water.

2. BACKGROUND

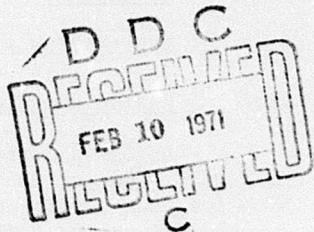
Drawbar pull (DBP) tests are conducted to enable an evaluation of vehicle operating characteristics under full and part throttle conditions. The data obtained from these tests serve as a basis for comparison with similar vehicles. This data also serves to predict gradeability and indicate how well a vehicle will perform as a prime mover of various loads.

Drawbar pull is a basic measure of the power output of a vehicle over and above that required to propel the vehicle on a level road, which can be utilized in acceleration, hill climbing, or towing trailed loads. Tests are conducted to establish performance curves that can be used in evaluating and comparing vehicles operating either on hard surfaces or in adverse soils. (Both wheeled and tracked vehicles are evaluated by the same procedures, with some variations caused by differences in design).

In addition to standard level road performance tests, amphibious vehicles are also tested for drawbar pull in water.

3. REQUIRED EQUIPMENT

- a. Hard Surface Road (level bituminous or concrete)
- b. Adverse soils
- c. Water for amphibious vehicles
- d. Laboratory dynamometer
- e. Payload or combat weight
- f. Drawbar
- g. Speed measuring fifth wheel
- h. Engine tachometer
- i. Sprocket or wheel counters
- j. Slip meter
- k. Fuel flowmeter



*Supersedes Ordnance Proof Manual 60-72

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- .. Timing device
- m. Thermocouples
- n. Temperature and pressure indicators
- o. Manifold pressure (vacuum) gage
- p. Meteorological instruments
- q. Control vehicles

4. REFERENCES

- A. MTP 2-2-603 Vehicle Fuel Consumption
- B. MTP 2-2-700 Laboratory Tests of Reciprocating Internal Combustion Engines
- C. MTP 2-2-501 Amphibious Vehicle Characteristics

5. SCOPE

5.1 SUMMARY

In order to form a basis for comparison with similar vehicles, two types of road tests are carried out, hard surface tests and soil tests. The results of these tests must provide sufficient data for an accurate evaluation of drawbar pull characteristics, relationship between engine and road speed, slippage, and full load fuel consumption (MTP 2-2-603). This MTP document describes these tests and lists the minimum data requirements necessary for accomplishing the test objectives.

Tests to determine the drawbar pull of amphibious vehicles in water are also discussed, along with the data requirements for evaluating and comparing these vehicles with similar equipments. These tests are usually conducted under stall conditions with the engine operating at various speeds.

5.2 LIMITATIONS

Preparatory operations are required for all production vehicles except those to be tested in the "as received" condition, those to be tested to determine the effect of endurance operations, and those to be tested for comparison with base line performance previously established by a calibrated vehicle.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Engine and Transmission

Engine and transmission will be prepared for maximum performance (properly tuned per individual vehicle specifications). In order to determine installed power, with and without all accessories, and to provide comparison with specifications (MTP 2-2-700), obtain an engine calibration on a laboratory dynamometer.

6.1.2 Vehicle

All pertinent adjustments, such as brakes, throttle linkage, track tension, tire inflation, and ignition timing, etc shall be made to comply with specifications.

All components shall be lubricated with the proper quantity and grade of lubricant, and proper levels will be maintained throughout the test.

When conducting drawbar pull tests, the vehicle shall be loaded with its normal payload or combat weight. Actual or simulated payload/weight shall be prepared in advance.

6.1.3 Instrumentation

Instrumentation requirements may vary somewhat with individual test vehicles; care should be exercised to make certain that the instruments adequately cover the expected range without undue sacrifice of sensitivity. All instruments shall be calibrated before installation and as often thereafter as necessary to insure accurate measurements.

Normally, instrumentation used covers the following: drawbar, speed-measuring fifth wheel, engine tachometer, sprocket or wheel counters, slippmeter, fuel flowmeter, timing device, thermocouples, temperature and pressure indicators, manifold pressure gage, and the necessary meteorological instruments to determine ambient temperature, humidity, and atmospheric pressure.

6.1.4 Restrictions

1. Tests shall not be conducted during precipitation or when the course condition does not provide good traction on hard surface.
2. Hard surface tests will not be conducted at road speeds at which wheel or track slippage is sufficient to cause damage to the vehicle or the test course surface, or when drawbar pull is appreciably affected. Maximum slippage will normally be held to 15 percent.
3. Tests shall be suspended when vehicle performance is subnormal, unless caused by meteorological conditions. Atmospheric pressure, for instance, has a direct bearing on engine performance, but is regarded as a test variable for which corrections can be made.
4. All test operation on hard surfaced roads will be under full throttle, full-load conditions. This is not applicable when operating in soils when drawbar pull versus slip is the principal interest.
5. Safety of personnel and equipment may limit the maximum road speed at which the tests are conducted. Forty miles per hour is the normal maximum.
6. No test data shall be recorded until the test vehicle has been operated until component temperatures have stabilized as required for normal performance. This is a requirement for obtaining repeatable data.

7. Hard surface tests will be conducted on level bituminous concrete under full throttle, full load conditions.

6.2 TEST CONDUCT

6.2.1 Hard Surface Tests

Hard surface tests are conducted to establish performance curves that can be used for evaluating or comparing vehicles operating under similar conditions. Available power at the vehicle pintle will be measured in all gear combinations over the vehicle speed range at full throttle and at discrete points in the normal engine operating speed range. Observations made at various road speeds should be sufficient to delineate accurately the representative curves. (See Fig. 1). Test results must yield an accurate evaluation of drawbar pull characteristics, relationship between engine and road speed, and full-load fuel consumption (MTP 2-2-603). Test results must also serve as a basis for comparison with data from tests on other similar type vehicles.

In the case of tracked vehicles with any type of fluid coupling (torque converter), it is also desirable to obtain maximum pull under stall conditions. To prevent slippage, it may be necessary to tie down the tracks when making this measurement.

6.2.2 Soil Tests

Vehicle operation over adverse soils shall be observed at a sufficient number of increments of slip or road speed to accurately establish the shape and magnitude of all curves. (See Fig. 2). Test results must yield an accurate evaluation of drawbar pull characteristics at various wheel slippages and provide sufficient data for comparison with similar vehicles.

To determine drawbar pull and track or wheel speeds relative to the ground during operation in adverse soils, power at the pintle will be measured in the approximate range of 20 to 80 percent slip as controlled by the dynamometer load. Slip above 80 percent has little practical value, while slip below 20 percent is difficult to measure. However, if vehicle design and soil conditions permit obtaining reasonable accuracy in the 0- to 20-percent slip range, power measurements shall be taken.

A control vehicle is normally used. Although comparison of results with data from similar vehicles can be made without a control if soil conditions are nearly alike, it is preferable to run comparative tests concurrently.

6.2.3 Water Tests

Drawbar pull for amphibious vehicles is evaluated under stall conditions by means of a connection to shore. Drawbar pull for amphibious vehicles at various water-speeds will be measured by towing a boat (or another amphibious vehicle), the latter in reverse propulsion, to the extent necessary for "loading" the test vehicle at the various test vehicle speeds. The towed

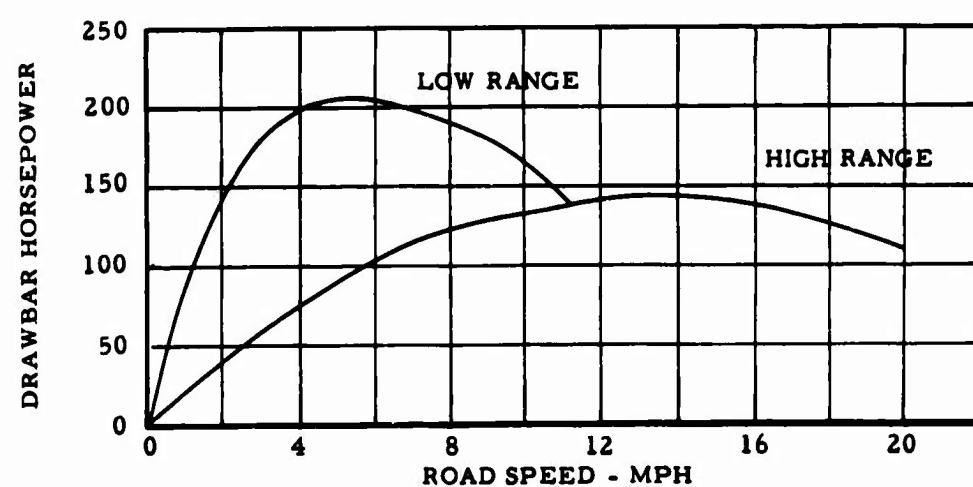
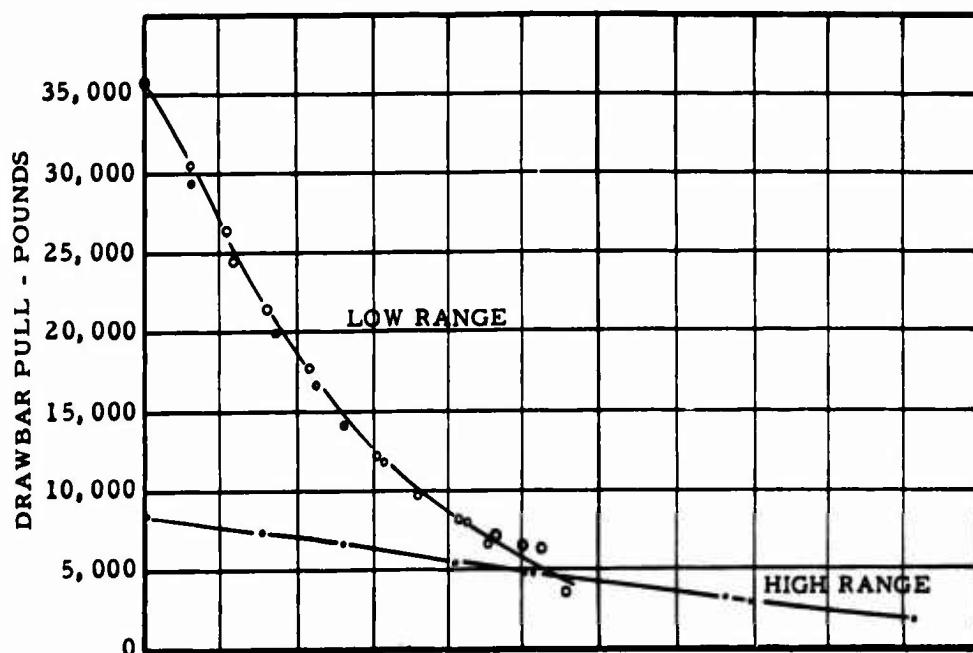
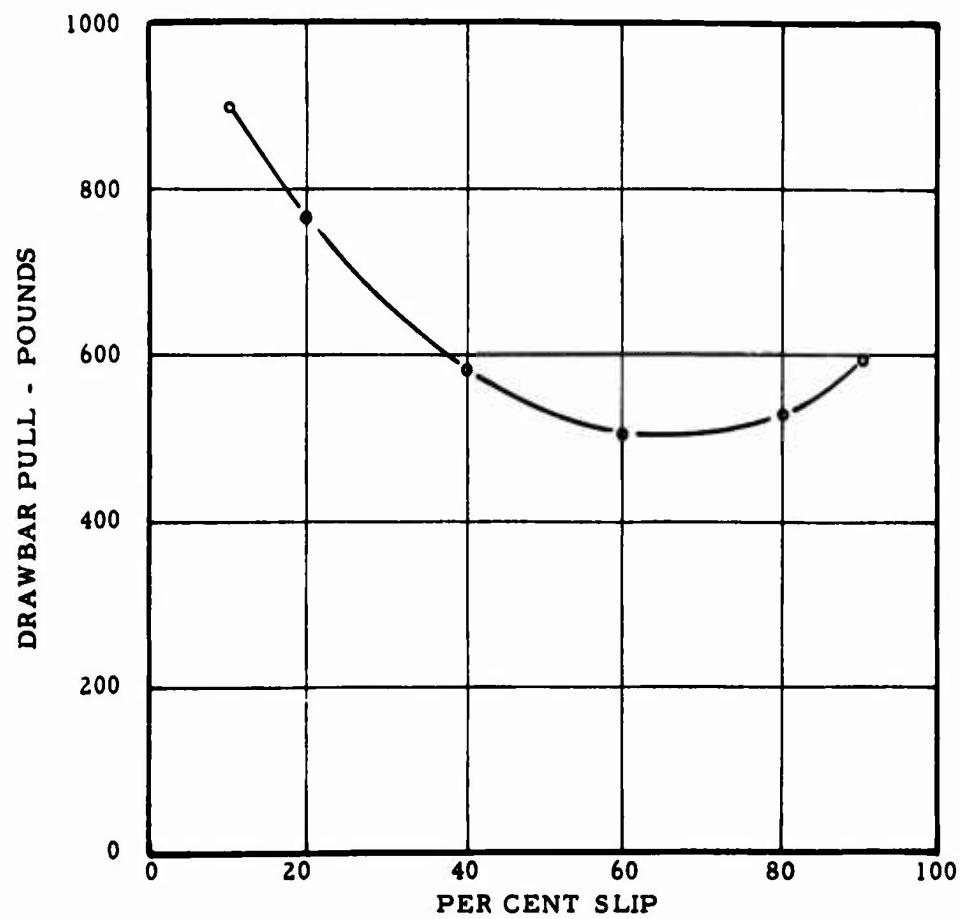


Figure 1. Drawbar Pull and Horsepower

Characteristics on Hard Surface



(All graphs of this type should identify the vehicle under test and include all pertinent information regarding test conditions. This information is either shown in the heading of the graph or noted by making reference to the appropriate portions of the test report.)

Figure 2. Drawbar Pull Versus Slip Characteristics in Sand

item is thus comparable with the dynamometer "load" towed by wheeled or tracked vehicles on land. Care must be exercised to insure that water depth is sufficient to give true values (MTP 2-2-501).

Test results shall provide sufficient data for an accurate evaluation of drawbar pull characteristics at various engine and sprocket, and propeller or wheel speeds; for comparison with similar vehicles; and for establishing the shape and magnitude of all curves (See Fig. 3).

6.3 TEST DATA

6.3.1 Hard Surface Tests

Record the following data:

- a. Drawbar pull (pounds) for each gear or range
- b. Engine speed (revolutions per minute)
- c. Road speed (miles per hour)
- d. Fuel consumption (pounds per hour or cubic centimeters per hour)
- e. Track or wheel speeds
- f. Meteorological data
 - 1. Ambient temperature
 - 2. Humidity
 - 3. Atmospheric pressure
- g. Oil pressures, as required for the particular power package to insure proper performance
- h. Temperatures, as required for the particular type power package
- i. Resistance to tow
- j. Overall gear ratio for each gear or range

6.3.2 Soil Tests

Record the following data:

- a. Drawbar pull (pounds)
- b. Slip (percent)
(Slip can be determined directly with a slipmeter on vehicles using standard gearbox transmissions; however, in the case of hydraulic transmissions, speed counters are necessary.)
- c. Engine speed (revolutions per minute)
- d. Track or wheel revolutions
- e. Distance traveled (feet)
- f. Depth of penetration (inches)
- g. Moisture content of soil (percent of dry weight)
- h. Vehicle weight

6.3.3 Water Tests

Record the following data:

- a. Drawbar pull (pounds) for stall and for various water speeds

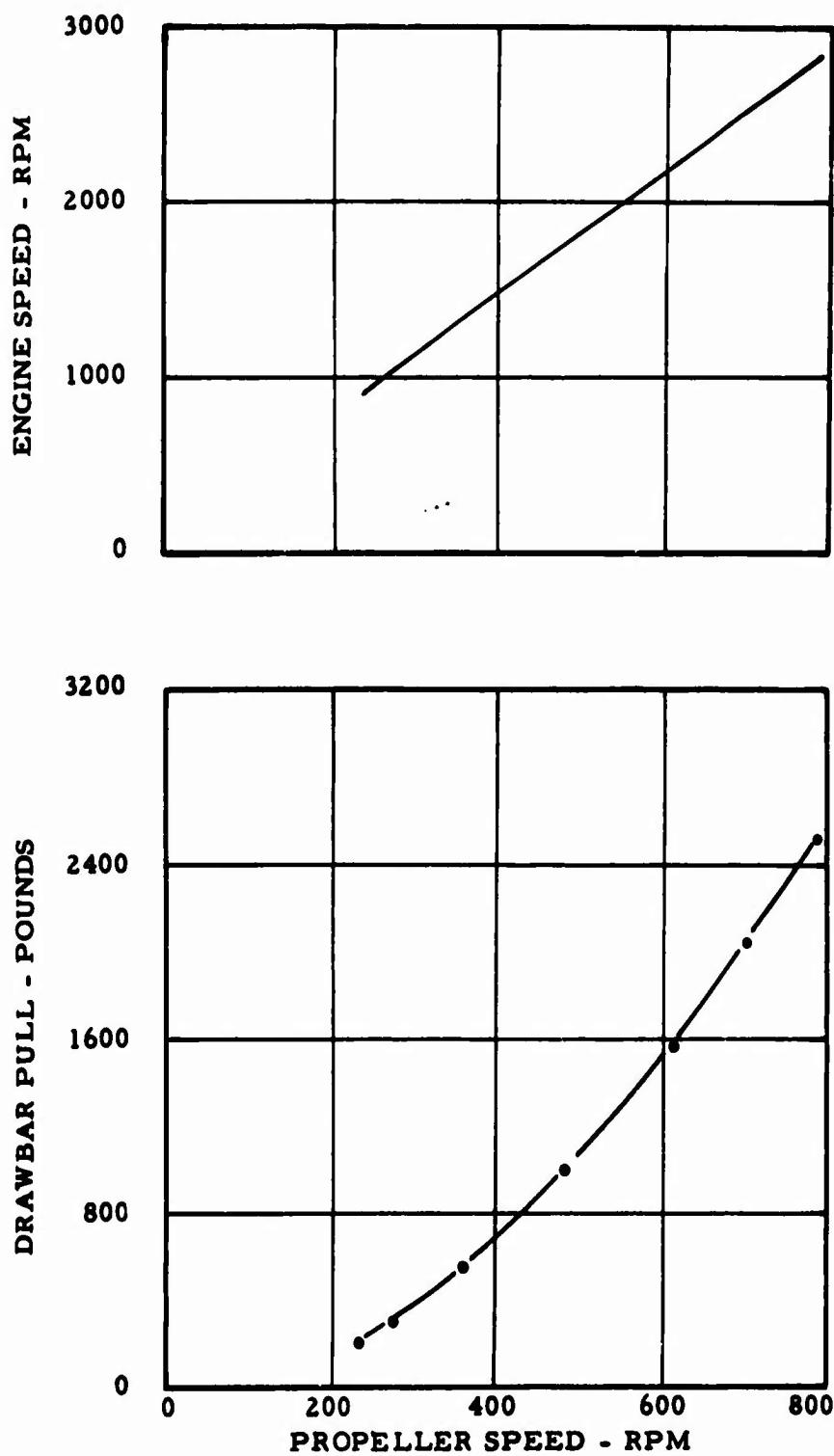


Figure 3. Drawbar Characteristics Under Stall Conditions in Water

- b. Engine speed (revolutions per minute) for stall and for various water speeds
- c. Propellant device speed (revolutions per minute) for stall and for various water speeds
- d. Approximate depth of water (feet)
- e. Freeboard (inches)

6.4 DATA REDUCTION AND PRESENTATION

Drawbar pull characteristics are appraised in terms of compliance with specifications, comparison with similar equipment, and conformance with theoretical or design data.

6.4.1 Hard Surface Tests

In presenting results, the values used for calculated data (drawbar horsepower, etc.) are taken from a curve averaging observed data. The computation for drawbar horsepower (DBHP) is as follows:

$$DBHP = \frac{\text{Road Speed (mph)} \times \text{Pull (lb)}}{375}$$

Drawbar pull (DBP), when using direct mechanical transmissions, may be computed for those gear ranges that cannot be safely or accurately measured in field testing because of insufficient traction or high speeds. Calculations are based on the measured pull in a lower gear at a specific engine speed, the ratio of the overall ratios in the gear ranges considered, and the measured resistance to towing at the road speeds. On this basis and at the same engine speed, the approximate DBP is computed using the following formulas:

Computing for higher gear -

$$DBP_2 = \left(DBP_1 + R_1 \right) \frac{OGR_2}{OGR_1} - R_2$$

Computing for lower gear -

$$DBP_1 = \left(DBP_2 + R_2 \right) \frac{OGR_1}{OGR_2} - R_1$$

Where:

DBP_1 = Drawbar pull (pounds) in lower gear

DBP_2 = Drawbar pull (pounds) in higher gear

R_1 = Resistance to tow (pounds) at road speed for DBP_1

R_2 = Resistance to tow (pounds) at road speed for DBP_2
 OGR_1 = Overall gear ratio for lower gear
 OGR_2 = Overall gear ratio for higher gear
 S_1 = Road speed for lower gear
 S_2 = Road speed for higher gear
 $S_2 = S_1 \times \frac{OGR_1}{OGR_2}$

6.4.2 Soil Tests

Results of soil tests shall be presented in the form of curves:

- Drawbar pull (pounds) vs percent slip
- Drawbar pull (percent of vehicle weight) vs percent slip

6.4.3 Water Tests

Results of water tests shall be presented in the form of curves.

When the tests are conducted under stall conditions the following curves shall be prepared:

- Propeller speed (rpm) vs drawbar pull (lbs)
- Propeller speed (rpm) vs engine speed (rpm)

When vehicle speed in water is obtained, a curve indicating vehicle speed (mph) vs drawbar pull (lbs) shall be prepared, in addition to the two "stall test" curves.

